Lat 40.81893 Lon -121.11723

Forest Pest Management

Pacific Southwest Region

File Code: 3420 Date: January 5, 2001

Subject: Insect and Disease Input to the Big Jacks Analysis Area (NE00-23)

To: District Ranger, Hat Creek Ranger District, Lassen National Forest

SUMMARY

The following report summarizes information collected during aerial and field surveys made during the summer and fall of 2000. The forest ecosystems within the Big Jacks analysis area are showing signs of forest health stress. This stress is primarily the result of overstocked stands, past periods of below average precipitation and in some cases fire suppression. Old and current conifer mortality, although not extensive, is apparent within the analysis area. This mortality is the result of bark beetle attacks, root disease centers and overstocking. Basal area measurements taken from some stands within the analysis area exceeded 400 sq. ft/acre. Although this basal area may be maintained during periods of adequate moisture levels during protracted periods of below normal precipitation an increase in mortality will likely occur. More over-story pine and pole-sized mortality should be expected within this area over the next few years as a result of the current stand densities. Management alternatives such as thinning and the reintroduction of fire can increase the health and vigor of residual trees, enable the growth of trees adapted to the site and create/enhance tree species diversity, thus lowering the susceptibility to damage caused by insects and pathogens. A more in-depth Forest Pest Management evaluation of the area is recommend prior to any management decisions.

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Existing condition

The Big Jacks analysis area is located in the northwest corner of the Lassen National Forest. The vegetation is dominated by ponderosa pine and basin sagebrush. Juniper is present in the northern part of the area with pockets of white fir occurring throughout the area. The analysis area ranges in elevation from about 1450 to 1800 meters. Average annual precipitation ranges from 20-25 inches. Site indices range from a Dunning 3 to 5.

Conifer mortality occurs throughout the analysis area. All size classes of pine have been affected but mortality is most apparent in the large over-story trees and in the tight pockets of pole sized trees distributed throughout the analysis area. This mortality can be attributed to an insect and disease complex of western pine beetle (WPB), mountain pine beetle (MPB), black stain root disease, annosus root disease and dwarf mistletoe. There is some current and older white fir top-kill and whole tree mortality along FS road 35N08.

Two different root diseases were found in the analysis area. One of them Annosus root disease (annosus conk) was found in a pine stump just west of Schroder Lake in the southwest part of the Big Jacks analysis area. The disease does not appear to be widespread at this time, but further surveys are needed to further identify the extent of this disease. Annosus root disease was not found in white fir trees in the Big Jacks area, but it is likely present. Black stain root disease was also found infesting a 14-acre stand of pine just west of Schroder Lake in the southwest part of the Big Jacks analysis area.

Mistletoes are found growing on trees throughout the Big Jacks analysis area. True mistletoe infections range from heavy to light, and occur mainly on Western juniper. Western dwarf mistletoe is found on ponderosa and Jeffrey pine in various parts of the Big Jacks analysis area. In areas where pine seedlings have established under infested overstory pines (i.e. between FS roads 34N22Y and 34N20), the understory is usually heavily infested. This pathogen is present on pine of all sizes and ages and infections range from heavy to light.

Ponderosa /Jeffrey Pine

Ponderosa pine and Jeffery pine mortality has been increasing throughout the analysis area for the past few years. This increase in pine mortality can be attributed to overstocking, black stain root disease; annosus root disease and elevated bark beetle activity. Current and older group kills are present throughout the area. The bark beetles associated with this mortality are the western, mountain, and Jeffrey pine beetle. Pine engraver has also cause top kill and mortality in small diameter trees in this area. Heavy infestations of western dwarf mistletoe are present in a few ponderosa/Jeffrey pine stands throughout the Big Jacks area.

Western pine beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensively studied and has proven to be an important factor in the ecology and management of ponderosa pine throughout the range of this host species. This insect breeds in the main bole of living ponderosa pine larger than about 6 inches in diameter. Group killing of trees is common in dense, overstocked stands of pole and saw-timber. It can breed in over-mature slowly growing trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees

continuously from spring through fall. Sapwood of infested trees usually shows evidence of the associated bluestain fungi (*Ceratocystis minor*) introduced by attacking beetles. Depending on the latitude and elevation, there can be from one to four generations per year.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In California, drought stress may be the key condition influencing outbreaks in that healthy trees undergo sudden and severe moisture stress facilitating the buildup of western pine beetle populations. The thick, nutritious phloem and inner bark of healthy trees become host material for attacking beetles. Healthy trees ordinarily produce abundant amounts of resin, which pitch out or eject attacking beetles. But, when deprived of moisture, stressed trees cannot produce sufficient resin flow to resist attack. Any condition that results in limiting the amount of water available to each tree, such as tree crowding, competing vegetation or protracted drought periods; or any condition that reduces that ability of the roots to supply water to the tree, such as mechanical damage, root disease, or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers, predaceous beetles and low winter temperatures are natural control agents.

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae*, attacks the bole of ponderosa pine larger than about 4 inches in diameter. Trees are usually killed by the beetles of a single generation. The mountain pine beetle is generally associated with trees under stress from such factors as competition with other trees, infection with dwarf mistletoe, root disease, other pathogens, or infestations with other insects. In stands of fairly young trees (75-100 years old) the beetle tends to act as a thinning agent in dense stands. Sapwood of infested trees usually shows evidence of the associated bluestain fungi (*Ceratocystis minor*) introduced by attacking beetles. Depending on the latitude and elevation, there can be from one to two generations per year.

The food supply regulates populations of the beetle. A copious pitch flow from the pines can prevent successful attacks. The number of beetles, the characteristics of the tree, and the weather, affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include low winter temperatures, nematodes, woodpeckers and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and mortality increases.

Pine Engraver

The pine engraver beetles, *Ips spp.*, attacks weakened or dying pines, usually in the tops and limbs of mature trees and in the bole of pole-sized trees. Under favorable conditions it has demonstrated the ability to kill trees, particularly those weakened by dwarf mistletoe or drought and in some instances apparently healthy trees of small diameter. Ips beetles help to accelerate the recycling of woody material by introducing wood decay fungi in host sapwood. Engravers also create gaps and introduce diversity into dense stands when they kill groups of young pines. An important cause of top-kill in large ponderosa pine, pine engraver attacks create special habitats for certain wildlife species. There can be several generations in one year depending on the temperature.

Pine engravers are most commonly associated with stressed or wounded trees and down material,

particularly of smaller diameters. Any activity or event that generates abundant amounts of fresh slash or stressed trees is likely to lead to elevated engraver populations. In a year of "normal" precipitation, pine engraves are generally confined to down or severely stressed hosts and do not kill healthy trees.

Red turpentine beetle

The red turpentine beetle*, Dendroctonus valens*, occurs throughout California and can breed in all species of pines. It normally attacks injured, weakened or dying trees and freshly cut stumps. The adults are attracted by fresh pine resin. They often attack wounded trees in campgrounds or following logging; trees scorched by wildfire or prescribed burns, lightning-struck trees and root-diseased trees exhibiting resinosis. Attacks do not typically kill trees but may predispose them to attack by other bark beetles. Repeated or extensive attacks by the red turpentine beetle can kill pines.

Dwarf Mistletoe

Dwarf mistletoes (*Arceuthobium spp*.) are obligate parasites. They grow exclusively on living conifer stems and branches. They obtain most of their nutrients and all of their water and minerals from their hosts. Western dwarf mistletoe (*A. campylopodum*) infects principally ponderosa and Jeffrey pines, and occasionally lodgepole pine. White fir dwarf mistletoe (*A. abietinum f.sp. concoloris*) can infect white and sugar pine (rare).

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From over-story to under-story, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe maybe vectored by birds and animals. Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, and witches' brooms in the lower crown, and bole swellings.

Dwarf mistletoe–infested stands are generally more flammable than healthy stands due to the large amounts of fuel arising from the accumulations of dead witches brooms fallen trees and live brooms in the lower crown. Because of these fuels, normally nondestructive fires can become stand-replacing fires in stands with dwarf mistletoe.

Pine Dwarf mistletoe in the Big Jack area reached its current severity and extent partly because of the suppression of natural wildfire over the past century. Since deadwood develops more rapidly in and under dwarf mistletoe infested trees, diseased trees are more vulnerable to the effects of fire. Small, heavily infested pine trees have a high risk of being ignited or killed by the heat generated by ground fires. Heavily infested branches and dwarf mistletoe brooms growing near the ground are also likely to be killed or ignited by ground fire. When heavily infested mature pines grow above heavily infested pine regeneration (i.e. ladder fuels), ground fires can flare up and consume the overstory. In these ways reintroducing fire may maintain a lower level of dwarf mistletoe infestation in the big Jacks area than currently exists

Annosus root disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos* spp. and *Artemisia tridenta*) are occasional hosts. The disease has been reported on all the National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in this Region. Current estimates are that the disease infects about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees, the loss of the site for future wood production, and in recreation areas, depletion of vegetative cover and increased probability of tree failure.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root contact into the root systems of adjacent live trees, resulting in the formation of enlarging disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of *H. annosum* have major differences in host specificity. All isolates of *H. annosum* from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the "S" group. This host specificity is not apparent in isolates from stumps; with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after

their roots contact infected roots in the soil.

Black Stain Root Disease

Is considered a tree-killing disease of conifers and is caused by the fungus *Leptographium wageneri.* Three varieties of the fungus exist, each generally confined to different hosts (ponderosa/Jeffrey pine, Douglas fir and pinyon pine). While some other conifers have been infected, only the trees mentioned have suffered significant losses to the disease in California. The ponderosa/Jeffrey pine variety of black stain is caused by *L. wageneri* var. *ponderosum*.

Black stain infection begins in the roots of a tree and advances toward the main stem. Fungal hyphae colonize the sapwood tracheids, causing vascular wilt and a characteristic stain in the wood. As the disease progresses, less and less water is transported from the tree's roots to its foliage. Most infected trees exhibit symptoms of decline and typically are killed by bark beetles. The pathogen, aided by bark beetles, can kill a mature tree in less than two years or it may take many years. There is no way to cure a tree of the disease, although some trees survive infection.

Stands that are most likely to be damaged by black stain root disease (high risk stands):

- have a high percentage of ponderosa or Jeffrey pine in the over-story;
- are overstocked;
- are generally cooler, wetter sites;
- have a history of site disturbance which contributes to tree stress and increased activity of insect vectors;
- have a pine over-story of merchantable size (generally > 40 years old).

Any one of these conditions alone or even a majority of the conditions do not necessarily indicate a risk for black stain root disease. In fact, it may be that most, if not all of these conditions must be present in order for the disease to cause significant tree loss. Under such conditions, tree mortality can become a chronic problem, eventually resulting in nearly complete elimination of mature pine from an area.

Crown thinning is the single best indicator that a tree's roots are unhealthy. Generally, the lower branches are the first to show symptoms, but as disease progresses the entire crown may become involved. Needle retention and length will be reduced, as will shoot elongation. Needles will be restricted to the ends of branches, giving a "lion's tail" appearance. Needles may be chlorotic, especially in the advance stages of the disease. These crown symptoms are not specific to black stain. They can also result from poor site conditions and other root diseases.

As the disease progresses within a tree, the probability of a lethal bark beetle attack increases and diseased trees are typically killed by these beetles. Non-lethal attacks of the red turpentine beetle frequently precede those of other bark beetles and pitch tube of the red turpentine beetle may be an indicator of advanced disease.

Because the disease will move from tree to tree through roots, mortality will typically involve a group of trees, referred to as a "disease center." Long-dead snags and fallen jacks-strawed trees indicate where the disease started. Progressing outward there will be more recently dead trees, trees with thin crowns, and finally trees without symptoms. This pattern of mortality and symptoms indicates the progression of the disease through a stand over time. Black stain and

annosus root diseases can both produce this pattern.

If black stain root disease is present in a tree, it is usually easy to confirm. Under normal conditions, black stain will progress to the root collar of the tree and slightly up the main bole before the tree is killed. Positive identification is made by finding the characteristic black stain in the sapwood of one or more suspected trees. The stain is distinguished on the basis of color, presence of resinosis, and its location in the sapwood. It is dark brown to almost black; typically, but not always, occurs in resin-soaked wood; and advances longitudinally through the outer sapwood, having an orientation in cross-section that is more tangential than radial.

Black stain root disease is uncommon in young pine stands and mixed conifer stands, and is rarer and appears less damaging in pine stands that are well spaced. Insect vectors of the disease are attracted to wounded trees, fresh stumps, and probably trees that are stressed. Logging activity results in an increase in vector abundance and provides them breeding habitat in the form of stumps. It may also result in soil compaction and root damage. Overstocked stands may be stressed due to competition, which can also increase vector activity. Stands with a high pine component provide the ideal environment for rapid disease spread. Repeated stand entries, especially during spring months when vectors are active and soils are wet and more subject to compaction, may encourage the disease. A copy of "Black stain Root Disease of Ponderosa Pine in California" (CDF: Tree Notes number 25; July 2000) is enclosed for your reference.

White fir

White fir can be found as a component of the eastside pine type found along the FS road 35N08. In some areas dense stands of white fir in the under-story are apparently out-competing the large over story pines. Regeneration of pine is almost absent as the more shade-tolerant white fir is a better competitor within these ecosystems. White fir is a more short-lived species and does not tolerate extended periods of moisture stress as well as ponderosa pine.

White fir top-kill and mortality, is fairly extensive, and has been occurring within the analysis area for several years now. The mortality over the past few years has been a result of competition from overstocking, possibly moisture stress, and fir engraver attacks.

Fir engraver

The fir engraver (*Scolytus ventralis)* is the most important bark beetle attacking white fir in California. It attacks and can kill nearly all age classes. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4 inches in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many species of bark beetles cannot develop successful broods without first killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

There does not seem to be a recognizable pattern of fir engraver outbreaks in California. When outbreaks do occur their simultaneous occurrence in many widely separated localities, causes severe damage to forests. Sporadic outbreaks have been recorded in California and Oregon at least

once a decade since 1925. Dry sites, drought and root disease play important roles in the susceptibility of true fir to fir engraver, and they are probably the most important factor influencing the food supply for beetles. Under adequate moisture regimes, overstocking of fir stands and high infection rates by root disease are the principal factors involved in predisposing trees to attack by fir engraver.

Western Juniper

Western juniper, *Juniperus occidentalis,* can be found as a major tree component of the analysis area along the A22 road and small patches distributed throughout the area.

True Mistletoes

True mistletoe (*Phoradendron densum*) is commonly found growing on Western juniper in the Big Jacks area. True mistletoes are parasitic plants usually having small, green leaves and round, white to light pink berries. They can only survive in living tissues, principally as a parasite utilizing water and minerals from the host.

This parasite is spread mainly by birds, including robins, bluebirds, thrushes, phainopeplas, and cedar waxwings. Birds feed on the berries, digest their pulp, and excrete the living seed, often depositing them onto susceptible trees. A viscous coating and hair-like threads on the outer surface of the seeds attach them firmly to twigs and branches, where they germinate and infect host tissues.

In nearly all cases, initial infection occurs on the branches of larger or older trees because birds prefer to perch in their tops. Severe buildup of mistletoe often occurs in an already-infected tree because birds are attracted to and may spend prolonged periods feeding on the mistletoe berries.

Heavily mistletoe infected trees are weakened, have a reduced in growth rate, and sometimes killed outright by the infection. Weakened trees are predisposed to attacks by insects and often die during drought or other periods of stress. Severe infection can result in top-kill. Branches and treetops heavily laden with true mistletoe often break during windstorms, increasing the hazard to people and property in campgrounds and other developed sites.

True mistletoe is recognized by the clumps of mistletoe foliage in the tree. These mistletoe plants are usually in the tops of larger, older trees. With severe infections, mistletoe plants may replace virtually all of the tree's foliage.

Management Alternatives

The following alternatives are general and specific management options that can be applied to the analysis area. More site-specific evaluations, including field evaluations to determine the insect and pathogen interactions, may be needed to develop management alternatives that lead in the direction of a desired future condition.

General

(1) **No action** - The current overstocked condition of Big Jacks area will continue to increase.

With this increase in biomass, and the periodic periods of below average precipitation that occur in northeast California there is an increase in the probability of bark and engraver beetle-related mortality throughout the area. Areas infected with dwarf mistletoe are expected to have an increase in the spread and intensification of existing infections. Existing black stain root disease centers are expected to expand radially as long as susceptible host are present. Continued susceptible tree mortality is also expected within these centers. Although some mortality may be desired for snags, small openings and for future down woody debris, the no action alternative will most likely result in unacceptable levels of mortality.

(2) **Prescribed fire and thinning**- Thinning is perhaps the most critical silvicultural treatment available to restore and maintain forest health. Historically, natural fire kept the trees and the understory vegetation in the Big Jacks analysis area at lower densities. With fire exclusion over the last century, many understory trees and shrubs have become established in the area. This vegetation (trees, shrubs, grasses and forbs) is competing with the old growth conifers for moisture and light. During the protracted drought in the early 1990's some old growth conifers in the area died as a result of moisture stress, which in combination with various diseases, weakened the trees and allowed various bark beetles to successfully attack.

If the management objective is ecological restoration in the Big Jacks analysis area, fire needs to be reintroduced into the area. Pre-treatment, including mechanical thinning and removal of the shrubs, ladder fuel and litter around residual trees would be required prior to reintroducing fire.

Fires of sufficient severity to consume the built up duff and litter can scorch the bark, cambium and foliage of pine trees produce types of injury, which make certain trees more attractive to bark and /or engraver beetles. Many trees, which have been only moderately injured by a fire and are capable of recovering may be attacked and killed by beetles after a fire. The attraction of fire-injured trees often causes a concentration of beetles within a burned area, which lasts for one to two seasons following a fire. While fire-injured trees can attract bark beetle in considerable numbers they do not always afford favorable breeding conditions for new broods. Some of the factors involved in post-fire bark beetle attacks are: level of stress prior to a fire (i.e. drought stress), bark beetle population levels prior to a fire and timing of salvage operations. Fires that result in cambium damage create open entry points for pathogens. Several brown and white rots can enter trees through fire scars.

Pine Dwarf mistletoe in the Big Jack area reached its current severity and extent partly because of the suppression of natural wildfire over the past century. Since deadwood develops more rapidly in and under dwarf mistletoe infested trees, diseased trees are more vulnerable to the effects of fire. Small, heavily infested pine trees have a high risk of being ignited or killed by the heat generated by ground fires. Heavily infested branches and dwarf mistletoe brooms growing near the ground are also likely to be killed or ignited by ground fire. When heavily infested mature pines grow above heavily infested pine regeneration (i.e. ladder fuels), ground fires can flare up and consume the overstory. In these ways reintroducing fire may maintain a lower level of dwarf mistletoe infestation in the big Jacks area than currently exists.

(3) **Thinning Overstocked Stands** - Thinning is perhaps the most critical silvicultural treatment available to restore and maintain forest health. Thinning from below reduces flammable fuels, creates growing space for trees and can provide a receptive seedbed for conifer seeds. Silvicultural prescriptions designed to reduce basal areas should result in lower levels of bark

beetle and black stain root disease related mortality in the future. Mortality would continue to occur and fluctuate in response to the amount of available moisture, but at levels that, through time, would more closely approximate naturally occurring mortality. Thinning can decrease the need to enter stands to conduct salvage operations, decrease the amount of fuel loading and reduce the number of hazard trees.

In less dense forests snags, down woody material and nutrient cycling would occur at more natural levels. Thinning should improve growing conditions, result in reduced mortality of large diameter trees, and release mid-diameter trees so they can grow into large diameter classes. Leaving a diversity of residual tree species after thinning is desired because bark beetles and diseases are fairly host-specific. Diversity should insure that some trees would survive elevated stress periods. Removing competing vegetation from plantations will reduce the susceptibility to various insects, which often cause damage to regeneration. Dependent upon slash treatment, there would be some level of risk of subsequent top-kill and/or whole tree mortality to residual conifers due to pine engravers that reproduce in green slash. When thinning stands trees with heavy dwarf mistletoe can be removed. In areas of heavy dwarf mistletoe concentrations openings may be created when all the heavily diseased trees are removed.

When harvesting conifers, treatment of freshly cut stump surfaces with a registered borate compound (Sporax) can prevent infection of the stumps and subsequently the root systems with annosus root disease. Because no economically feasible procedure for directly suppressing the disease is available, prevention through the use of borate is the most efficient and economical method of reducing future impacts of *H. annosum*. Likewise, no direct control has been found for black stain root disease. On sites with a history of black stain, some general rules should be used to guide management decisions: encourage a mixture of tree species, keep stands from becoming over stocked, and limit stand treatments to times and activities that are less likely to promote the disease. Because *Leptographium wageneri* requires a living host in which to survive, the fungus dies out in infected trees that have been cut and is not likely to infect stumps of uninfected trees.

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